Optional Infiltration Protocol

Purpose

To determine the rate at which water soaks into the ground as a function of time

Overview

Students place two cans into the soil and add water to them to a depth of at least 5 cm. Students measure and record the time it takes the water level to drop a fixed 2 - 4 cm distance. Students repeat the measurement to determine how easily water moves vertically through the soil.

Student Outcomes

Students will be able to measure water infiltration into soil. Students will understand that the infiltration rate of water into soil changes depending upon the level of soil saturation. Students will understand that water that is not stored in the ground evaporates or becomes runoff and may pool on the surface for a time. Students will be able to determine how flood-prone an area is based on the infiltration rate of the soil.

Science Concepts

Physical Sciences

Objects have observable properties.

Earth and Space Sciences

Earth materials are solid rocks, soil, water, biota, and the gases of the atmosphere.

Soils have properties of color, texture and composition; they support the growth of many types of plants.

The surface of Earth changes.

Soils consist of rocks and minerals less than 2 mm, organic material, air and water.

Water circulates through soil changing its properties.

Scientific Inquiry Abilities

Identify answerable questions.

Design and conduct an investigation.

Use appropriate mathematics to analyze data.

Develop descriptions and explanations using evidence.

Communicate procedures and explanations.

Time

One class period to build and test the double-ring infiltrometer.

45 minutes or one class period for the measurement.

Level

All

Frequency

Three or four times a year at the Soil Moisture Study Site

One time at a Soil Characterization Sample Site

In all cases, three sets of measurements should be taken within a radius of 5 m.

This protocol can be done while samples are collected for the *Gravimetric Soil Moisture Protocol.*

Materials and Tools

Metal ring with a diameter of 10 - 20 cm

Metal ring with a diameter 15 - 25 cm (Coffee cans work!)

Buckets or other containers to transport a total of at least 8 L of water to the site

Ruler

Waterproof marker

Stop watch or watch with a second hand

Block of wood

Hammer

Three soil sample containers suitable for soil moisture measurement

Grass clippers

Funnel

Preparation

Build an infiltrometer.

Prerequisites

None

Optional Infiltration Protocol - Introduction

Infiltration rate is determined by measuring the time it takes for water sitting on a soil to drop a fixed distance. This rate changes with time as the soil pore spaces fill with water. There are three flow rates.

Unsaturated flow is the initial flow rate and is high as the dry soil pore spaces fill with water.

Saturated flow is a steady flow rate that occurs as water moves into the soil at a rate determined by soil texture and structure.

Ponding is the flow rate that occurs when the ground becomes totally saturated and is no longer able to conduct water through its pores.

Teacher Support

Site Selection

Students should select a location within 2 - 5 m of a Soil Moisture Site or a Soil Characterization Site. Students need to be careful that they do not leave a hose running where the water will flow over their soil moisture sampling points.

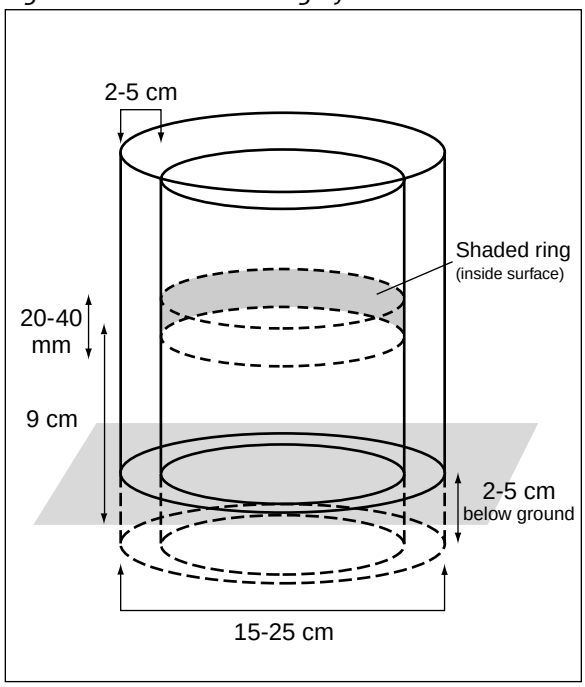
Advance Preparation

Before beginning the infiltration protocol, students need to construct an infiltrometer to measure the infiltration rates of the soil. Students should use the following procedure to construct their infiltrometers.

Construct a Dual Ring Infiltrometer

1. Cut the bottom out of your cans.
2. Use a permanent waterproof marker or paint to partially shade a ban on the inside of the smaller can to use as a timing reference mark. The width of the band should be 20-40 mm and centered roughly 9 cm from the bottom of the can. Many cans have impressed ribs that make good reference marks but it is still necessary to mark them for good visibility.
3. Measure and record the width of your reference band (in mm).

Figure SOIL-IN-1: Double-ring infiltrometer



4. Measure and record the widths of your inner and outer rings (in cm).

Have students practice this protocol, including the timing, at a site where there is easy access to water so that they become comfortable taking the measurements. If students practice in a sandy location, the infiltration time intervals will be short and they will have more opportunities to practice taking measurements in a limited time period.

Managing Materials

Students can use either a stopwatch or a watch with a second hand to time the water flow into the soil. When students use a stopwatch, they should begin timing as water is first poured into the inner ring. They should record the elapsed time as the start time and end time of water moving over a fixed distance.

Infiltration Protocol
Field Guide

Task

To determine the rate at which water soaks into the ground as a function of time

What You Need

- ❑ Infiltrometer (see advanced preparation section)
- ❑ Buckets or other containers to transport a total of at least 8 L of water to the site
- ❑ Ruler
- ❑ Waterproof marker
- ❑ Stop watch or watch with a second hand
- ❑ Block of wood
- ❑ Hammer
- ❑ Three soil sample containers suitable for soil moisture measurement
- ❑ Grass clippers
- ❑ Funnel

In the Field

1. Clip any vegetation (grass) to the ground surface and remove all loose organic cover over an area just larger than your largest can. Try not to disturb the soil.
2. Starting with the smaller can, twist the cans 2 - 5 cm into the soil. A hammer may be used to pound the can into the surface. If you must use a hammer, a block of wood should be used between the hammer and the top of the can to distribute the force of the hammering. Do not hammer so hard that the can crumples.
3. Complete the upper section of the *Soil Infiltration Data Sheet.* If you are using a stop watch, start it.
4. Pour water into both rings. Maintain a level in the outer ring approximately equal to the level in the inner ring. Note that the water level in the outer ring tends to drop more quickly than that of the inner ring. In the inner ring, pour water to just above the upper reference band. **Note**: The outer ring should not be leaking water to the surface around its rim. If it is, start over in another location, push the outer ring deeper into the soil or pack mud around its base.
5. As the water level in the inner ring reaches the upper reference mark, read the stop watch or note the time to the second. This is your start time. Record this time on the *Infiltration Data Sheet*. During the timing interval, keep the water level in the outer ring approximately equal to the level in the inner ring, but be careful not to pour water into the inner ring (using a funnel can help) or to let either ring go dry.
6. As the water level in the inner can reaches the lower reference mark, record the time as your end time.
7. Calculate the time interval by taking the difference between the start and end times. Record this interval on your *Infiltration Data Sheet*.

8. Continue repeating steps 4 - 7 for 45 minutes or until two consecutive interval times are within 10 sec. of one another. Some clays and compacted soils will be impervious to water infiltration and your water level will hardly drop at all within a 45-minute time period. In this case, record the depth of water change, if any, to the nearest mm. Record the time at which you stopped your observations as the end time. Your infiltration measurement will consist of a single interval.
9. Remove the rings. WAIT FIVE MINUTES.
10. Measure the near-surface (0 - 5 cm depth) soil moisture from the spot where you just removed the rings. Follow the *Gravimetric Soil Moisture Protocol*. You only need take one sample.
11. Make two other infiltration measurements within a 5 m diameter area. These measurements can be done at the same time using other groups or over several days (if the near-surface soil water content is not changed by rain). It is not critical that multiple runs have the same number of reading sets, but do not submit runs that are incomplete (e.g. a run that was cut short due to lack of time). If you take more than three sets of measurements, submit your three best sets.

Infiltration Protocol – Looking at the Data

Infiltration rate is determined by dividing the distance that the water level decreases by the time required for this decrease. For GLOBE measurements this is equal to the width of the reference band on the infiltrometer divided by the difference between the start and end times for an interval.

The *Infiltration Data Sheet* can be used to record and help calculate the values needed to plot measurement results. The flow rate for each timing interval is the average value during an interval. The flow rate should be plotted at the *midpoint* of the interval times. Infiltration should decrease with time and it is important to keep track of the *cumulative* time from when water was first poured into the inner ring. The table and graph below demonstrate how to calculate infiltration rates and plot them on a graph.

Figure SOIL-IN-3: Infiltration

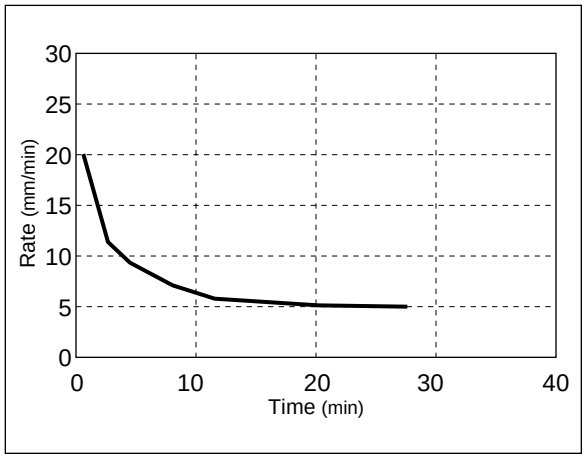


Figure SOIL-IN-2: Infiltration into Jim's Garden

Water Level Change = 20 mm

Time							Flow
Start		End		Interval	Midpoint	Cumulative	Rate
[min]	[sec]	[min]	[sec]	[min]	[min]	[min]	[mm/min]
31	00	32	00	1.00	31.50	0.50	20.0
32	30	34	15	1.75	33.38	2.38	11.43
34	30	36	45	2.25	35.62	4.62	8.89
37	15	40	00	2.75	38.62	7.72	7.27
40	45	44	00	3.25	42.38	11.38	6.15
44	15	47	45	3.50	46.00	15.00	5.71
48	15	52	00	3.75	50.12	19.12	5.33
52	15	56	15	4.00	54.25	23.25	5.00
56	30	00	30	4.00	58.50	27.50	5.00

Soil Investigation

Soil Infiltration Data Sheet

Site Name: _____

Name of Collector/Analyst/Recorder: _____

Sample collection

- date: _____
- time: _____ (hours and minutes) check one: UT____ Local ____

Distance to Soil Moisture Site _____ m

Sample Set number: _____ Width of your reference band: _____mm

Diameter: Inner Ring: _____ cm Outer Ring: _____ cm

Heights of reference band above ground level: Upper : _____ mm Lower : _____ mm

Directions:

Take 3 sets of infiltration rate measurements within a 5 m diameter area. Use a different data work sheet for each set. Each set consists of multiple timings of the same water level drop or change until the flow rate becomes constant or 45 minutes is up. Record your data below for one set of infiltration measurements you take.

The form below is setup to help you calculate the flow rate.

For data analysis, plot the Flow Rate (F) vs. Midpoint time (D).

Observations:

	A. Start (min) (sec)	B. End (min) (sec)	C. Interval (min) (B-A)	D. Midpoint (min) (A+C/2)	E. Water Level Change (mm)	F. Flow Rate (mm/min) (E/C)
1	___ ___	___ ___	_____	_____	_____	_____
2	___ ___	___ ___	_____	_____	_____	_____
3	___ ___	___ ___	_____	_____	_____	_____
4	___ ___	___ ___	_____	_____	_____	_____
5	___ ___	___ ___	_____	_____	_____	_____
6	___ ___	___ ___	_____	_____	_____	_____
7	___ ___	___ ___	_____	_____	_____	_____
8	___ ___	___ ___	_____	_____	_____	_____
9	___ ___	___ ___	_____	_____	_____	_____

Saturated Soil Water Content below infiltrometer after the experiment:

A. Wet Weight: _____ g B. Dry Weight: _____ g C. Water Weight (A-B): _____ g

D. Container Weight: _____ g E. Dry Soil Weight (B-D): _____ g

F. Soil Water Content (C/E) _____

Daily Metadata/Comments: (optional) _____

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